A COLLECTION OF SOME PAPERS

Formerly published in the

Philosophical Tranſactions,

Relating to the Uſe of

Dr. KNIGHT's Magnetical Bars,

With ſome NOTES and ADDITIONS.

LONDON:
Printed in the Year MDCCLVIII.

An Extract *of the* Minutes *of the* Royal Society, *of* February 19, 1746.

The Preſident in the Chair.

THE Preſident read a paper, containing an account of ſome magnetical experiments which he, in company with *William Jones*, Eſq; ſaw on *Wedneſday* the 11th of this inſtant *February*, at the houſe of Dr. *Gowin Knight*.

The doctor, he ſays, having produced two ſquare bars of harden'd ſteel, of the length of about 15 inches, and of the breadth and thickneſs of about half an inch, and to which he had communicated a ſtrong magnetic virtue, laid thoſe bars down upon a table, ſo as to be nearly in a ſtrait line, the north pole of the one being next to the ſouth pole of the other, and at the diſtance of about half an inch from it. A ſmall flat piece of natural loadſtone was then placed between theſe bars, ſo as to be in contact with the ends of them both, that were next to each other; where when it had only remained a few moments, it was found that upon taking it out, the part of the ſtone which had been contiguous to the north pole of the bar, attracted the north end of the compaſs needle, and that the part of the ſtone which had been contiguous to the ſouth pole of the other bar, attracted in like manner the ſouth end of the ſame compaſs needle; and this in whatever poſition the natural loadſtone was placed between the bars: ſo that, in theſe experiments, the poles of the ſtone were firſt inverted, and then ſet at right-angles to the direction in which they at firſt lay.

That Dr. *Knight* then gave a ſtrong touch to two large ſea compaſs needles, the one temper'd, and the

other quite hard; which was done by placing them, ſucceſſively, one half part upon one bar, and the other half part upon the other; and then drawing away the bars, till they were clear of the needles: by which operations, both the needles not only acquired a ſtrong verticity, but were alſo enabled to lift with either of their ends a weight of better than an ounce and an half.*

That theſe two needles were then applied to each other; firſt, the northern end of the one, in a contrary direction to the northern end of the other, and then the ſouthern end of the firſt in like manner to the ſouthern end of the other; from which poſitions, being drawn aſunder, it was found, that the temper'd needle had in a manner loſt all its virtue, but that the other would ſtill, with either of its ends, lift better than half of the weight it lifted before.†

That Dr. *Knight* then touched upon the large bars one of his ſmall common magnetic bars, in the ſame manner as he had juſt before touch'd the large needles; and this bar, which was applied in a contrary direction of the polarity it already had, had its poles thereby inverted, and lifted after the touch, with one of its ends, better than 6 ounces and 8 penny-weights.

* The weight here made uſe of conſiſted of two pieces of ſoft iron, joined together with wax, each piece weighing about 15 penny-weights; which weights were ſent from *Deptford*, as a ſtandard of the ſtrength of a needle touch'd upon their loadſtone, one of the weights being the utmoſt which that loadſtone could make a needle lift. Wherefore this experiment ſhews, that theſe magnetic bars would give a touch twice as ſtrong as the *Deptford* loadſtone, for it made the needles lift two ſuch weights; they alſo made the needle of hardened ſteel lift as much as the tempered one.

† The intention of this experiment was to ſhew how much more durable the magnetic virtue was, when communicated to a needle quite hard, than when given to a needle temper'd of a ſpring temper (as it muſt be when touched upon a natural loadſtone) for by this rough treatment the temper'd needle was render'd quite uſeleſs, whereas the harden'd one was yet a ſtronger than they could make at *Deptford*.

That

That Dr. *Knight* laſtly produced one of his large artificial armed magnets, compoſed of thin plates of ſteel cramp'd together, with which he lifted before them 31 pounds and 9 ounces. That with this magnet, by touching in the common way the temper'd needle upon its armed poles, he again reſtored ſo much of its former virtue, as to lift with one of its ends about three quarters of an ounce.*

And that by touching in like manner, but in a contrary ſenſe, the hard needle (which yet retained a great ſhare, as it was obſerved, of its former virtue) he not only deſtroy'd the ſame, but gave it a new polarity the contrary way; but that it would not, after this new touch, lift more than 9 penny-weights; that is to ſay, not half what it lifted when touch'd upon the large ſteel bars.†

The preſident had thanks for this report; after which, Dr. *Knight* produced before the ſociety the two large bars, and all the other particulars mention'd in the report, with which he repeated publickly all the ſeveral experiments mention'd above, and which, notwithſtanding all the diſadvantageous circumſtances of the place, ſucceeded perfectly in every particular, to the ſatisfaction of the company.

It being then propoſed, that the temper'd needle, having its virtue again deſtroy'd, ſhould be touch'd on the fine *Terella* belonging to the ſociety (which was the noble preſent of their very worthy member, the right honourable the late earl of *Abercorn*, is eſteemed one of the beſt in *England*, and is ſaid to have lifted in his lordſhip's hands upwards of 40 pounds) the ſame was immediately brought up, and the needle

* This experiment ſhews, that the armed magnet gave a touch nearly of the ſame ſtrength with the loadſtone at *Deptford*, and that the former method of touching with the two bars was much preferable both to the touch of the natural loadſtone, and of the beſt artificial magnets when armed.

† Whence it appears that an hard needle receives but little virtue from an armed magnet, when touch'd in the common manner.

being touch'd therewith, it was found to have acquired a ſtrong polarity, and to lift about the ſame weight, as when touch'd on the doctor's large armed artificial magnet, that is to ſay, about 15 pennyweights.*

The thanks of the ſociety were given to Dr. *Knight*, for his curious experiments then ſhewn before them.

An account of ſome new improvements in artificial magnets, communicated to the Royal Society *by* Gowin Knight, *M. B. F. R. S.* June 4, 1747.

THE *apparatus* for touching of needles (which I lately had the honour to ſhew to the ſociety) was as perfect as I could have wiſh'd, as far as relates to the intended uſe of it; but the manner in which the two bars were diſpoſed in their caſe, render'd the length of them ſomewhat incommodious, eſpecially in thoſe of the largeſt ſize. This made me deſirous of trying if ſome method could not be found out, of placing the bars parallel to each other, without danger of weakening their force; by which means the caſes would be reduced to half their length. I remember'd that ſome years ago I had tried ſome experiments to this purpoſe by placing ſome bars parallel, and in contact, but ſo that their poles were turned different ways; in which poſition I found the virtue of ſome of them remain'd pretty entire, but that others were weaken'd thereby. I imagined the reaſon of their loſing their force was this; that the magnetic virtue was by degrees habituated to paſs out of the ſide of one bar into that of the other in contact with it, and thereby was hinder'd from arriving

* This experiment only ſerves to ſhew, that this celebrated loadſtone gives a touch nearly the ſame with that at *Deptford*, and the armed magnet abovemention'd; ſo that the two moſt eſteem'd loadſtones in the kingdom will not give a touch, even to a temper'd needle, of more than half the ſtrength of one touch'd by theſe bars, and it is well known that no natural loadſtone will give a good touch to an harden'd needle.

at

at the ends in its full vigour. The reaſon why ſome ſuffer'd more than others, was doubtleſs to be aſcribed to their difference in temper. I repeated the experiment about two months ago with a little alteration. I placed the bars parallel, with their poles in an alternate poſition, as before, but not in contact; having kept them at the diſtance of about a quarter of an inch. Then I applied to their ends two pieces of ſoft iron. Each piece was laid a-croſs, from the north end of one bar to the ſouth of the other; in the ſame manner as the lifter is apply'd to the feet of an armed loadſtone. The intention of this was, to draw the magnetic virtue thereby down to the ends of the bars, and to convey it through the pieces of iron from one bar to the other. In this condition I let them lay for about a month, and then tried if they would lift the ſame weight as before; which I found they did, and I thought with much more vigour. After this, I repeated the experiment with other bars of various ſizes, and with the ſame ſucceſs. I have therefore now ventured to fit them up in caſes, in the manner juſt deſcribed.

Some further experiments relating to the general phænomena of magnetiſm, by the ſame.

Read December 17, 1747.

THE cauſe of the ſurpriſing *phænomena* of the loadſtone has hitherto eſcaped our knowledge, though diligently inquired after by men of the greateſt abilities. Such a diſcovery is not to be made without long experience, and a great variety of facts: and the nature of the ſubject is ſuch, that the more facts we are acquainted with, the more we find ourſelves perplexed. The concluſions we draw from ſome experiments are

ſeemingly contradicted by others: and yet theſe ſeeming contradictions are oft-times very reconcileable upon further experience. If what I am about to lay before the Society will in any wiſe contribute to remove theſe difficulties, I am in hopes it will not be unacceptable, though I ſhould not ſo properly explain the nature of the cauſe, as the manner in which it acts. Many of theſe experiments are not altogether new, but have not been ſo much attended to as they ſeem to deſerve.

PROPOSITION I.

The magnetic matter of a loadſtone moves in a ſtream from one pole to the other internally, and is then carried back in curve lines externally, till it arrives again at the pole where it firſt entered, to be again admitted.

Experiment I.

If we lay a magnetical body under a piece of paper or glaſs that is ſtrewed over with ſteel filings or magnetical ſand, and by ſtriking the table put the filings in motion, they will readily diſpoſe themſelves in ſuch a manner as to repreſent, with great exactneſs, the courſe of the magnetic matter. Steel rendered magnetical is beſt for this purpoſe, becauſe it is of a more uniform texture than load-ſtones, and will on that account exhibit a more regular appearance. By this experiment the curve lines in which the magnetical matter returns back to the pole where it firſt entered are accurately expreſſed by the arrangement of the filings. The largeſt curves are ſuch as take their riſe from one polar ſurface, and are extended to the other; being larger in proportion as they ariſe nearer the axis or center of the polar ſurface. Thoſe curves which ariſe from the ſides of a magnetical body are always interior to thoſe which ariſe from the polar ſurface; and are leſs and leſs in proportion to their diſtance from the ends. If any one ſhould doubt, whether the magnetical matter, which thus diſpoſes the filings, is really moving back

in

in a direction contrary to that with which it paſſes through the magnetical body; let him try it in different parts with a ſmall compaſs needle, and the fact will appear beyond diſpute.

EXPERIMENT II.

The larger the diſtance is from pole to pole in different magnets, the larger will theſe curves be. This appears from examining magnets of different lengths. And this is the reaſon why in the ſame magnet the curves are leſs in proportion to their greater diſtance from the ends of the bars. For the poles from whence theſe curves ariſe are proportionably nearer to each other.

EXPERIMENT III.

If the ſouth pole of one magnet be oppoſed to the north of another, moſt of the magnetic matter is carried directly out of one into the other: and does not return back in curve lines till after having paſſed through both magnets. It appears from the arrangement of the filings that the magnetic matter proceeding from the polar ſurface does not now diverge from the axis as before, but runs more in ſtrait lines, till it arrives at the polar ſurface of the other magnet. The curves ariſing from the ſides, which before were bent towards the oppoſite end of the ſame magnet, are many of them now bent the contrary way towards the correſponding ſides of the other magnet. Thoſe which are not bent the contrary way are ſuch as are too remote from the oppoſed pole of the other magnet to be influenced thereby; and therefore continue their natural courſe.

EXPERIMENT IV.

Whilſt the bars are in the poſition of the laſt experiment, if a ſmall loadſtone be placed in the ſtream running from one to the other in any poſition whatſoever, the ſtream will paſs through the ſtone: which being again removed, will be found to have a polarity exactly in the direction of that ſtream.

EXPERIMENT V.

If the north or ſouth poles of two magnets be oppoſed to each other, the filings will exhibit the appearance of two ſtreams meeting; and the curves of each will be all turned towards the oppoſite pole of the ſame magnet. The appearance is altogether the ſame, whether the two north or the two ſouth poles be oppoſed to each other. So that it is not to be determined from any of theſe experiments at which of the poles the magnetic ſtream enters. As we have ſome reaſon to think it enters at the north pole, we may ſuppoſe that the caſe, without danger of error; provided we build nothing upon the ſuppoſition, but what would hold good (*mutatis mutandis*) if the contrary ſhould be true. This being ſuppoſed when the ſouth poles are oppoſite, the two ſtreams coming out at them are directly contrary, whereby the magnetic matter is accumulated, and therefore diverges ſo much the faſter to return back to the north poles. When the north poles are oppoſed to each other, the ſtreams of magnetic matter returning from the ſouth poles are directly contrary; and by crowding at once towards each polar ſurface, are accumulated betwixt them, and converge towards them ſo much the faſter.

Theſe five Experiments ſeem ſufficient to eſtabliſh the truth of the propoſition; and many more might be propoſed to the ſame purpoſe.

PROPOSITION II.

The immediate cauſe why two or more magnetical bodies attract each other, is, the flux of one and the ſame ſtream of magnetical matter through them.

EXPERIMENT VI.

It appeared in the third experiment, that when the ſouth pole of one magnet was oppoſed to the north

of

of another, a ſtream of magnetic matter was carried from one to the other, and did not return back to the pole where it firſt entered, till after having paſſed through both bars; and it is needleſs to obſerve that two bars in this poſition are in a ſtate of attraction. The fifth experiment ſhewed, that when the two ſouth or north poles were oppoſed, there was no ſtream common to both. Now it is well known, that magnetical bodies in this ſituation are ſo far from attracting, that they ſtrongly repel each other. If the third experiment be repeated, with the magnets placed at different diſtances from each other, we ſhall find that more of the magnetical matter will paſs from one polar ſurface to the other, in proportion as the diſtance betwixt it is leſs. The attraction is therefore greater as the diſtances diminiſh. And at diſtances where none of the magnetic ſtream paſſes from one magnet to the other, there is no ſign of attraction. So that this cauſe is not only co-exiſtent with the effect, but alſo proportionable thereto.

EXPERIMENT VII.

If a piece of ſoft iron, which has no fixed magnetiſm is any where placed in the magnetical ſtream, it will be in a ſtate of attraction whilſt it remains in that ſtream, and no longer.

EXPERIMENT VIII.

A ball of ſoft iron in contact with the pole of a magnet will attract a ſecond ball, and that a third, and ſo on, till the ſtream becomes too weak to produce an attraction ſufficient to ſupport a greater weight.

EXPERIMENT IX.

Having hung a number of balls to each other, by applying the firſt to the north pole of a magnet, upon preſenting the ſouth of another magnet to one of the middle balls; all thoſe below it will thereby be deprived of the magnetic ſtream, and inſtantly loſing their power of attraction fall aſunder: the ball, to

which the magnet was applied will be attracted by it, and all the others will ſtill remain ſuſpended. But if the north end of a magnet be preſented, then the ball to which it is applied will alſo drop.*

EXPERIMENT X.

In a magnet unarmed, the magnetic ſtream is carried back on all ſides in curve lines to the contrary pole, as was ſeen in *Experiment* I. but when armour is applied to each pole, the magnetic matter is thereby conducted to the feet of the armour; and a lifter being then applied to the feet, the whole ſtream coming out at one pole is carried back through it to the other; by which means the lifter is made to adhere to the feet of the armour with very great force. When the lifter is thus in contact, the magnet ſeems externally to have loſt the greateſt part of its force; though in reality it never acted with more. If inſtead of the lifter we ſuſpend a number of iron balls in contact, they will adhere together, and hang like a bracelet betwixt the two feet; the returning ſtream paſſing now through them, as before through the lifter. Preſent the pole of a magnet, and they inſtantly fall aſunder.

PROPOSITION III.

The immediate cauſe of magnetic repulſion, is, the conflux and accumulation of the magnetick matter.

It appeared in the fifth *Experiment*, that the ſame poles of two different magnets being oppoſed to each other, there was a conflux and accumulation of the magnetic matter; and we find by experience

* The laſt article in this Experiment ſhould not be tried with a pair of bars, whoſe force we wou'd preſerve entire, becauſe by bringing the ſame poles together, they will mutually weaken each other.

that

that all magnetical bodies in a like ſituation are in a ſtate of repulſion.

Experiment XI.

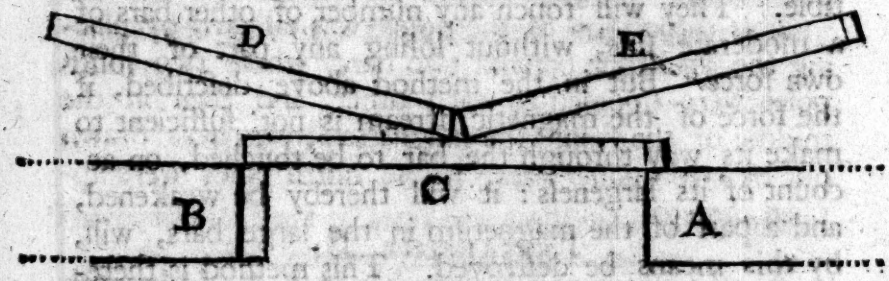
Two ſmall bars, the one hard, the other of a ſpring temper, being both magnetical, were oppoſed to each other, ſouth to ſouth; the filings produced the ſame appearance of repulſion, as deſcribed in the fifth *Experiment*; then the bars being brought ſo near as to touch each other at the ſame poles, the repulſion was inſtantly changed into attraction.

A method of making the large magnetical bars, deſcribed in the above minutes, of more extenſive uſe.

A Pair of large bars, that are perfectly hard, and rendered very ſtrongly magnetical, may be conſidered as a magazine of magnetiſm, that is inexhauſtible. They will touch any number of other bars of a moderate ſize, without loſing any part of their own force. But in the method above deſcribed, if the force of the magnetic ſtream is not ſufficient to make its way through the bar to be touched, on account of its largeneſs: it will thereby be weakened, and a part of the magnetiſm in the large bars, will, by this means be deſtroyed. This method is therefore beſt ſuited to the touching of needles and other ſmall pieces of ſteel, not exceeding 2 or 3 ounces, and as it is ſimple, and eaſily put in practice, it will do very well for moſt common purpoſes. But caſes may occur in a courſe of magnetical experiments, where larger bars may be deſireable; wherefore, I imagine the following manner of uſing the largeſt bars will be an acceptable communication to the publick; eſpecially as it is a more general and complete method

method of touching, though not quite ſo ſimple as the former.

Provide three bars of ſteel perfectly hard, and marked at one end for the north pole, each of which bars may be about one third of the weight of one of the large bars, and ſimilar, as to the proportion of its three dimenſions to each other, place the two large bars A B in in the ſame direction, with their north and ſouth poles oppoſed to each other, but at ſuch a diſtance, that one of the ſmaller bars C may reſt with its north end upon the ſouth of A, whilſt its other end reſts upon the north of the other large bar B; then apply the ſouth end of the ſmall bar D and the north of E to the middle of C, with their other ends elevated, ſo as to make an acute angle with the ſaid bar: draw D & E aſunder along the ſurface of the bar C, preſerving the ſame elevation all the way; then remove D and E to the diſtance of a foot or more from C and bringing the north and ſouth ends in contact, apply them to the middle of the bar C



as before, and repeat the ſame proceſs 3 or 4 times, after which, turn the bar C, and touch its oppoſite ſurface in like manner, and then the other two ſurfaces. The bar C will by this means acquire a conſiderable ſhare of fixed magnetiſm. In the next place, lay the bar D upon the ends of the large bars, and touch it with C and E on its four ſurfaces in the ſame manner. Then repeat the ſame operation upon E with the bars C and D. After each bar has been thus ſucceſſively touched 3 or 4 times, any two of them

them will ever after ſerve to touch other bars by proceeding in the ſame way.

In *April* 1745, I communicated to the *Royal Society* ſome experiments relating to the placing the poles of natural loadſtones in a very particular manner, but did not explain the means I made uſe of to produce thoſe effects. And whereas the method of touching above layed down, will enable any one to furniſh himſelf with bars, with which he may repeat the like changes in natural loadſtones, that are not too large: I will here relate the experiments as publiſhed in the Philoſophical Tranſactions (p. 361.) and ſubjoin the method I then uſed.

EXPERIMENT I.

I cut a piece of natural loadſtone into the ſhape of a parallelopiped 1 inch $\frac{3}{10}$ in length, in breadth $\frac{4}{10}$ of an inch, and $\frac{2}{10}$ in thickneſs: its weight 3 drams and 10 grains. In this ſtone I placed the magnetic virtue, in ſuch a manner that the two oppoſite ends became both of them ſouth poles, and the middle was quite round a north pole.

This diſpoſition of the poles was effected by placing the loadſtone betwixt two bars, whoſe two ſouth poles were oppoſed to each other, and then in the middle of the ſtone the magnetic ſtream was drawn out by two ſmaller bars, whoſe north poles were applied thereto.

EXPERIMENT II.

Another ſtone was in length 1 inch $\frac{1}{10}$ in breadth $\frac{7}{10}$, and in thickneſs about $\frac{2}{10}$ at a medium, it being thicker at one end than at the other: its weight 1 dram 57 grains. The two oppoſite ends of this ſtone I made both north poles, and the two ſides ſouth poles.

This experiment is nearly the ſame with the firſt, except that here the magnetic ſtream was drawn out at the two ſides of the ſtone by two bars, whoſe breadth was nearly equal to the length of the loadſtone.

Ex-

Experiment III.

An irregular ſtone that weighed about 5 ounces and a half, had two broad flat ſurfaces oppoſite to each other, at the diſtance of one inch and $\frac{3}{10}$. I made half of theſe ſurfaces a north pole, and the other half a ſouth pole, ſo that the north pole of one ſurface was oppoſite to the ſouth pole of the other ſurface, and *vice verſâ*.

Half of this ſtone was placed betwixt the north and ſouth poles of 2 large bars, ſo that half the flat ſurfaces were in contact with the bars: then the other half of the ſtone was placed in like manner betwixt the bars, but in a contrary direction.

Experiment IV.

I took a ſtone of a pretty good kind, that had a grain very apparent, running the lengthways of it. It was 1 inch $\frac{4}{10}$ in length; 1 inch $\frac{3}{10}$ in breadth, and the thickneſs at the ſides was $\frac{6}{10}$ of an inch, but in the middle $\frac{7}{10}$, it being tapered away from the middle to the ſides: its weight was 3 ounces wanting 4 grains. At one end of it I placed a north pole ſurrounded by a ſouth, and at the other end a ſouth ſurrounded by a north pole, ſo that the edges of each ſurface had a pole of a different denomination from that which occupied the middle.

The proceſs in this experiment was very ſimple and eaſy, it conſiſted in placing the ſtone betwixt the large bars to give it a ſtrong polarity, that was quite regular, and then to touch the whole ſurface, except the poles, with the pole of a leſs bar in a direction quite contrary to the firſt polarity; by this means the heart of the ſtone retains the ſtream of magnetiſm unaltered, whilſt that of the ſurface is inverted.

N. B. The bars for touching of needles are made of three different ſizes. The price of each pair is proportionable to the ſize of the bars. Thoſe of the dimenſions deſcribed in the minutes are ſold for ten guineas, the ſecond ſort for five guineas, the third ſort for two guineas and a half. The cautions neceſſary to be obſerved,

obſerved, in order to preſerve them in their full vigour, are — firſt, never to let the two north or two ſouth poles approach each other. Secondly, never to take one bar ſingly out of the caſe, but let them both ſlide out together upon a table, with the irons at their ends, and the partition betwixt them; then taking off one of the irons, move the two poles to which it adhered aſunder, in the manner you would open a pair of compaſſes, till the bars are brought to lay in a right line, the north pole of one bar being oppoſed to the ſouth of the other; then the other iron and the partition being removed, they are in a poſture fit for uſe. In reſtoring them again into the caſe, obſerve the ſame rule inverted. Thirdly, if you attempt to invert the poles of too big a loadſtone, or to touch a piece of ſteel of too large dimenſions, the bars will be weakened thereby. Theſe three ſorts of bars will touch the largeſt needles in uſe without danger of impairing their ſtrength, and invert any loadſtone not exceeding half an ounce in weight. Fourthly, never let them lay long near another loadſtone or magnet, or any large piece of iron or ſteel.

Theſe rules being obſerved, they will never loſe any thing of their force; and they may lay in any poſture when put up in their caſes.

All bars impregnated by Dr. *Knight* will have a certificate thereof, under his own hand, paſted upon the caſe; and at preſent are only to be had of the doctor himſelf at the *Britiſh Muſeum*.

An apparatus proper for trying the doctor's experiments may be had with the bars, for one guinea.

A letter from captain John Waddel *to Mr.* Napthali Franks, *merchant, concerning the effects of Lightning in deſtroying the polarity of a mariner's compaſs.*

ON the 9th of *January* 1748-9, the new Ship *Dover*, bound from *New York* to *London* being then in Lat. 47 30 north, and longitude 22 15 weſt from *London*, met with a very hard ſtorm of wind, attended with thunder and lightning as uſual, moſt part of the evening, and ſundry very large comazants (as we call them) over-head, ſome of which ſettled on the ſpindles at the top-maſt heads, which burnt

like very large torches; and at 9 p. m. a ſingle loud clap of thunder with lightning ſtruck the ſhip in a violent manner, which diſabled myſelf, and great part of the ſhip's company, in the eyes and limbs; it ſtruck the main-maſt about ⅓ up almoſt about half through, and ſtove the upper deck one carling, and quick-work; part of which lightning got in between decks, ſtarted off the bulk-head, drove down all the cabbins on one ſide of the ſteerage, ſtove the lower deck, and one of the lower deck main lodging-knees.

Another part of it went through the ſtarboard ſide, without any hurt to the ceiling (or inſide plank); and ſtarted off from the timbers four outſide planks being the whale upwards; one of which planks, being the ſecond from the whale, was broke quite aſunder, and let in, in about 10 or 15 minutes time 9 feet water in the ſhip.

It alſo drew the virtue of the loadſtone from all the compaſſes, being four in number, all in good order before, one in a braſs and three in wooden boxes. The hanging compaſs in the cabin was not quite ſo much diſabled as the reſt; they were at firſt very near revers'd, the north to the ſouth; and after a little while rambled about ſo as to be of no ſervice. The ſtorm laſted five days, we loſt our mainmaſt and mizenmaſt, and almoſt all our ſails; arriv'd at *Cowes* the 21ſt of *January* in a very ſhatter'd condition.*

* As the diſtreſs this ſhip was in for want of a compaſs, might have been remedied if the captain had had a pair of magnetical bars on board, it ſhould induce all captains of ſhips that are going on long voyages to provide themſelves with ſuch bars.

An account of the mariners compaſs, that was ſtruck with lightning, and ſhewn at the laſt meeting of the Royal Society; with ſome further particulars relating to that accident; communicated by Gowin Knight, *M. B. F. R. S.*

WHEN I came to examine the compaſs ſtruck with lightning, I obſerved that the outward caſe was joined together with pieces of iron wire, 16 of which were found in the ſides of the box, and 10 in the bottom. I applied a ſmall needle to each of theſe wires, and immediately perceived that the lightning had made them ſtrongly magnetical; particularly thoſe that joined the ſides. All the heads of the wires on one ſide of the box attracted the north point of the needle, and repelled the ſouth; whilſt all the heads on the other ſide attracted the ſouth and repell'd the north. The wires at the bottom attracted the ſouth and repelled the north; but it is not certain, whether this polarity was any-ways owing to the lightning; ſince it might be acquired by their continuing long in an erect poſture.

In examining the card, I found that the needle was vigorous enough in performing its vibrations, but that its polarity was inverted; the north point turning conſtantly to the ſouth. I then tried to take out the card, to examine the ſtate and ſtructure of the needle: but the junctures were every-where well-ſecured with putty, and that grown ſo hard, that I was obliged to uſe ſome violence, and at laſt broke the glaſs. The needle (if I may ſo call it) conſiſted of two pieces of ſteel wire, each of which was bent in the middle, ſo as to make an obtuſe angle; and the ends of theſe wires applied together, forming an acute one, the whole appear'd in the ſhape of a lozenge; in the centre of which was placed the braſs

cap

cap whereon the card turned. And ſo far was it from being made with any tolerable degree of exactneſs, that there was not the leaſt care taken either to bend the wires in the middle, or to fix the cap exactly in the centre of the lozenge: for, upon trying it with a pair of compaſſes, I found its greateſt excentricity to be full $\frac{2}{10}$ of an inch. The pin upon which it turned was made of a ſlip of plate-braſs ſharpened to a point.

Beſides the particulars already communicated to the ſociety, the captain informed me, that he was obliged to ſail above 300 leagues, after this accident happen'd, without a compaſs, till he arrived at *Cowes* in the *Iſle of Wight*; where being provided with one, he placed it in the binacle, but was much ſurprized to find that it varied from the direction it ſtood at when out of the binacle nearly two points. He removed the binacle to different parts of the deck, but found that it always made the needle to vary after the ſame manner when placed in it. He repeated the ſame experiment lately in the river, with the like ſucceſs; only that he obſerved, that the variation of the needle, when placed in the binacle, was rather leſs than at firſt. It was natural to inquire if there was any iron about the binacle; but I was ſurprized when the captain informed me, he had given ſtrict charge to the maker not to put ſo much as a ſingle nail in it; and that he firmly believed that there was not the leaſt bit of iron about it.

Being willing to be ſatisfied of the truth of a circumſtance ſo very extraordinary, the captain was deſired to ſend the binacle to a houſe in the city; where, in company with the captain, Mr. *Ellicott*, and another gentleman, I tried it with a large compaſs touched by my bars; but finding no ſenſible variation, we at that time deſiſted, thinking the fact quite improbable: but having diſcovered the effect which the lightning had produced upon the wires

which faſtened the ſides of the compaſs-box, I was induced to examine the binacle a ſecond time; which I did with a ſmall compaſs, and with great care, in every part; and at laſt, about the middle of the binacle, I found it to vary very ſenſibly, but could not diſcover any nails or iron any-where thereabouts; till, turning it up to examine the bottom, I there found 3 or 4 large nails, or rather ſpikes, driven thro' it, to faſten the upright partitions in the middle of the binacle.

It would not be difficult to explain why any needles, under the like circumſtances with thoſe above related, ſhould be render'd uſeleſs by lightning, tho' the needles themſelves had remained unhurt. So many iron wires made ſtrongly magnetical would doubtleſs have effected it; and 3 or 4 large nails in the binacle, if made magnetical, would alone have been ſufficient to have done it. But I have already taken notice that the polarity of the needle was inverted by this accident; and I would further obſerve, that all needles conſtructed after this manner are liable to be render'd uſeleſs, not only by the lightning's deſtroying their virtue, but alſo by its placing it in a particular direction; *e. g.* if the lightning ſtruck the needle in the direction of either of the two parallel ſides of the lozenge, it muſt ſtrike the other two ſides very obliquely; whereby the firſt two ſides may have their polarity deſtroyed, and a very ſtrong one given them in the contrary direction; whilſt that of the other ſides, if it be inverted, will be very weak; but it is probable that the virtue would be placed obliquely in the direction of the ſtroke; in either caſe, theſe two ſides can contribute but very little (if any thing) in directing the card; and if the two firſt ſides only are capable of acting upon it, it will point in the direction of thoſe ſides, which will produce a variation of about four points.

It may further be obſerved that a needle would not continue long in this ſtate, but would every day grow more and more regular; becauſe if the virtue be placed obliquely, it generally turns itſelf in the direction of any piece of ſteel that is long and ſlender; and that may be the reaſon why this card is now become regular, except that it is inverted.

The wires that join the box ſeem weaker than when I firſt examin'd them; which makes it very probable that they might be vaſtly ſtronger when firſt ſtruck with the lightning: and the ſame may be likewiſe true, in regard to the nails in the binacle; which may account for the experiment's not anſwering exactly the ſame as at firſt.

From what has been ſaid it appears, that this form of needles is very improper, and ought to be changed for that of one ſtrait piece of ſteel; and then if a needle ſhould be inverted it might ſtill be uſed. It alſo ſhews the abſurdity of permitting iron of any kind about the compaſs-box, or the binacle. Whoever conſiders the whole deſcription here given of this compaſs, I am perſuaded, he will eſteem it a moſt deſpicable inſtrument. How then muſt any one be ſhocked to hear, that almoſt all the compaſſes made uſe of by our trading veſſels, are of the ſame ſort! the boxes all joined with iron wire, and the ſame degree of accuracy obſerved throughout the whole!

This I am credibly informed is the caſe; and that for no other reaſon, but that one of this ſort may be purchaſed for 5 *s.* and it will coſt about 2 *s.* 6 *d.* more to buy a tolerable good one. So that the lives and fortunes of thouſands are every day hazarded for ſuch a trifling conſideration.

The imperfections of the common compaſſes in uſe, at the time of this accident, were ſo evident, that it was recommended to Dr. *Knight* to think of the beſt means of remedying thoſe defects. He accordingly applied himſelf to contrive a method

of

of conſtructing both ſteering and azimuth compaſſes, upon better principles than had hitherto been put in practice: both which kinds of compaſſes are now uſed on board his Majeſty's ſhips, and in many others, eſpecially where the captains are intelligent enough to be ſenſible of the faults of the old ones, and to judge of the perfections of theſe. They are made and ſold by Mr. *George Adams*, mathematical inſtrument maker to his Royal Highneſs the Prince of *Wales*, in *Fleet-ſtreet*: with a certificate of their having been examined by Dr. *Knight*: who has found by experience, that, without this precaution, his improvements would often be diſcredited, not only by the vain attempts of perſons quite ignorant of the common laws of motion and mechanicks, but alſo by the too great hurry or inattention of the workmen employed, even where the maſter has been fully inſtructed by the doctor in the principles to be obſerved, and, generally ſpeaking, was not wanting in care and abilities.

At the ſame place may be had a compaſs for obſerving the variation at land, lately contrived by Dr. *Knight*, with a certificate of its having been examined and approved by him.

F I N I S.